Influence of the Climatic Oscillations on the Sardine off Northwest Africa during the period 1976-1996

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INTRODUCTION

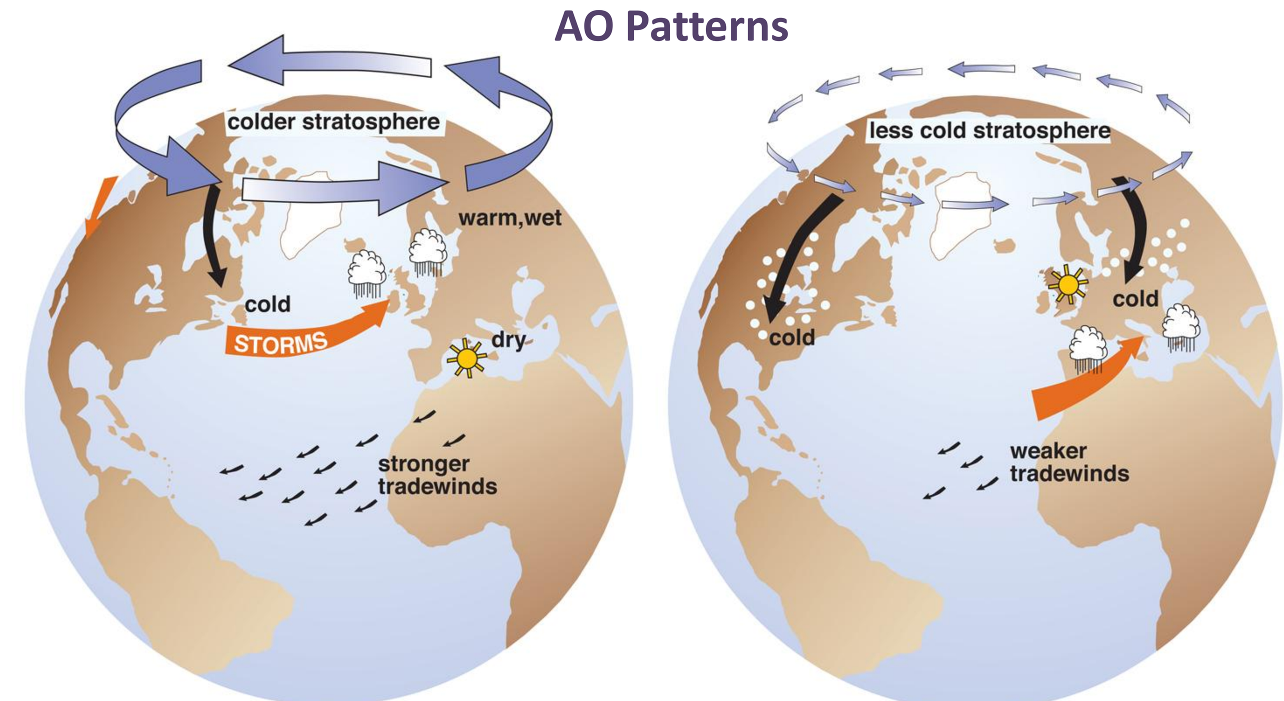
It is widely accepted that the planet is experiencing a period of rapid global warming (Oreskes, 2004) and also that their impact on marine biodiversity and fisheries ecology is primarily driven by human activity (Keller, 2007).

Small pelagic resources are prone to undergo the effects of climate change resulting in drastic fluctuation of biomass in large marine ecosystems (Checkley *et al*., 2009; Reid & Valdés, 2011; Alheit *et al*., 2012, 2014).

The Canary Current ecosystem is one of the four major eastern boundary upwelling systems of the world oceans. The Moroccan Atlantic continental shelf forms part of that ecosystem, characterized by its high biological productivity and its intensive fisheries where *Sardina pilchardus* represents the main landings (Kifani *et al*., 2008).

The main aim of the current study is to contribute to the knowledge of the possible effect of three main climatic indices from the Northern Hemisphere, the North Atlantic Oscillation (NAO), Atlantic Multidecadal Oscillation (AMO) and Arctic Oscillation (AO) on the variability of this resource.

AO Patterns



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METHODOLOGY

The sardine fishery data has its origin in the fishing activity of Spanish purse seine fleet in NW Africa from 1976 to 1996 developed within the Fishery Agreement between Spain-EU and Morocco. These fisheries data refer to *Zone B* (FAO statistical areas along the African coast between the parallels of 29°N and 26°N).

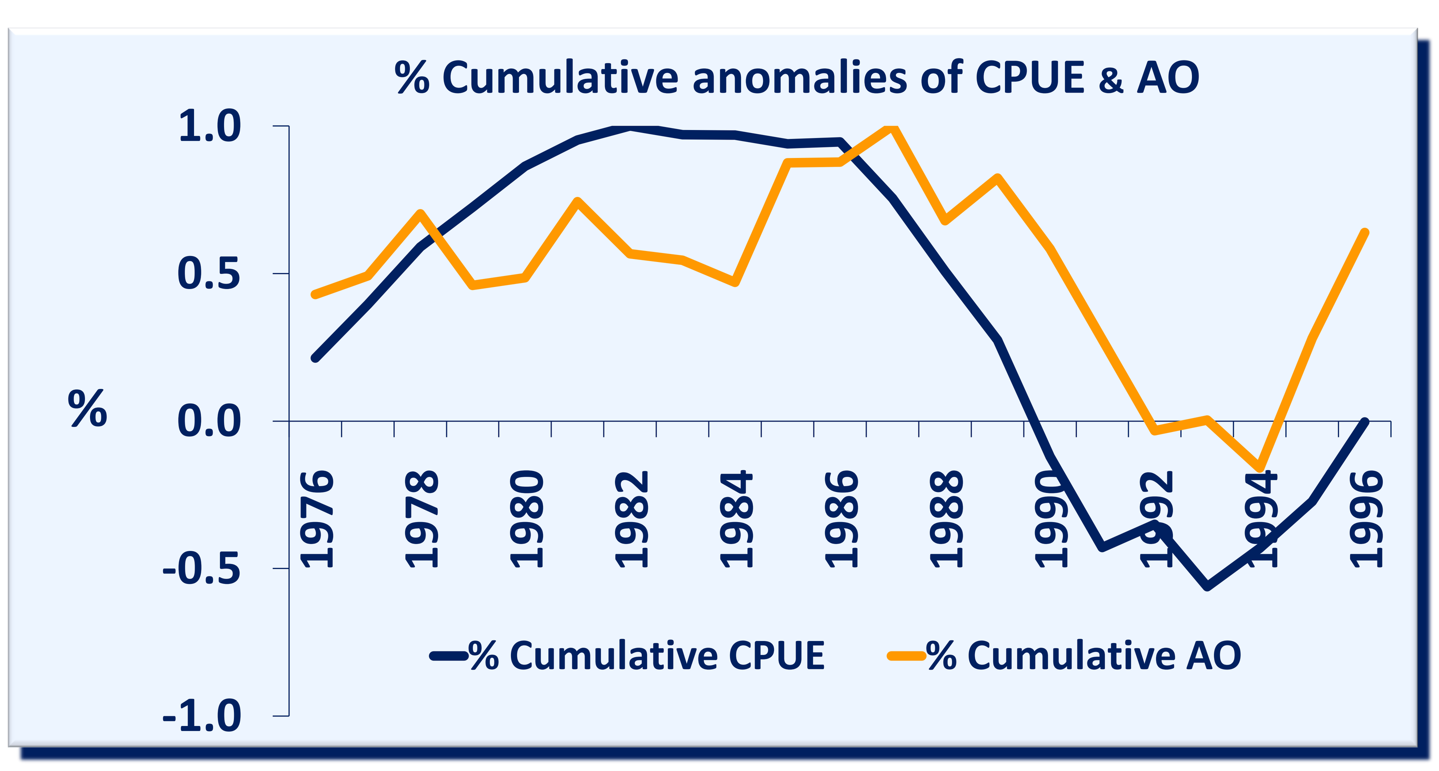
Monthly values of the NAO, AMO, and AO index were downloaded from the website of the National Oceanic and Atmospheric Administration: http://www.cpc.noaa.gov/. Firstly, we analyzed the time series for each variable. In order to identify periodicity or autocorrelation, we searched for common time trends and cyclicity in the time series using spectral analysis. Spectral analysis was performed with the software PAST (available from web site: http://folk.uio.no/ohammer/past/) (Hammer *et al*., 2001; Hammer & Harper, 2006).

Different regression models were applied using Catch per Fishing Days as Unit of Effort (CPUE) of sardine *versus* the climatic oscillations used as independent variables.
In addition, the sardine length-weight relationship was used to analyze the possible effect of climatic oscillations.
In this functional relationship, *b*= LogW/LogL-Log*a**1/LogL + Error, where *b* and *a* are the parameters of the L-W regression.

Therefore, we assume that this somatic relationship will vary in function of climatic oscillations, where *b*= f (-Log*a*, LogW/LogL, climatic oscillation) using the mean values of *a* and *b* per year and the different NAO, AMO and AO variables.

Since climate change may have expected time lags, different monthly time lags were used in the model (e.g, NAO1, NAO2, NAO3, AMO, AO1, AO2 and AO3) where a series of different multiple linear relationships were carried out.

RESULTS & DISCUSSION



No time trend autocorrelation or periodicity in the CPUE data was observed. However, the sardine CPUE from *Zone B* and the AO shows a significant positive relationship, where CPUE is the dependent variable and AO is the independent variable, according to the function:

$$CPUE_{sardine} = 73.879 + 12.46*AO \quad (R^2= 0.21;\ F= 5.047;\ p= 0.037)$$

In addition, the best model that we obtained for *b* was performed with the independent variables –Log*a*, NAO3 (i.e. NAO with a time lag of three months), and AO1 (i.e. AO with a lag of one month):

$$b= -Log_{10}a* 0.112+NAO_3*0.041- AO_1*0.004 \qquad (R^2= 0.863;\ F= 29.347;\ p<0.001)$$

The results indicate that there is an ecological cascade with a phase shift mediated by the NAO and the AO, which in the first instance refers to fitness and in a second instance to CPUE.

Despite uncertainties regarding the validity of trends observed in two decades, our results show that the AO affects the CPUE of sardine from *Zone B*. We assume that CPUE is being affected by the relative abundance of the sardine resource, because the positive AO phases can increase the intensity of trade winds (Marshal *et al*., 2001; Hall *et al*., 2014) and thereby, enhancing productivity in the zone and consequently influencing the physical condition or fitness of the fish.

Thus, global warming is influencing the sardine fishery production via AO in *Zone B* of Western Africa.

REFERENCES

Alheit *et al*. (2009). Decadal-scale variability in populations. *In*: Climate change and small pelagic fish. Edited by D.M. Checkley, J. Alheit, Y. Oozeki and C. Roy. New York, Cambridge University Press: 202-262. // **Alheit *et al*. (2012).** Climate variability drives anchovies and sardines into North Sea and Baltic Sea. *Progress Oceanography*, 96: 128-139. // **Alheit *et al*. (2014).** Reprint of "Atlantic Multidecadal Oscillation (AMO) modulates dynamics of small pelagic fishes and ecosystem regime shifts in the eastern North and Central Atlantic". *Journal of Marine Systems*, 133: 88-102. // **Hall *et al*. (2014).** Drivers of North Atlantic Polar Front jet stream variability. *International Journal of Climatology, 2*1: 1863-1898. **// Hammer *et al*. (2001).** PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, 4 (1): 9. // **Hammer & Harper (2006).** Paleontological Data Analysis. Blackwell Publishing, Oxford. **// Keller, C.F. (2007).** An update to global warming: the balance of evidence and its policy implications. *The Scientific World Journal*, 7: 381-39. // **Kifani *et al*. (2008).** The need of an ecosystem approach to fisheries: The Moroccan upwelling-related resources case. *Fisheries Research*, 94: 36-42. **// Marshal *et al*. (2001).** North Atlantic climate variability: phenomena, impacts and mechanisms. *International Journal of Climatology*, 21: 1863-1898. // **Oreskes, N. (2004).** The scientific consensus on climate change. *Science*, 306: 1686. // **Reid & Valdés (2011).** ICES status report on climate change in the North Atlantic. *ICES Cooperative Research Report* No. 310: 262 pp.